"On the Properties of the Arterial and Venous Walls." By JOHN A. MACWILLIAM, M.D., Regius Professor of Physiology in the University of Aberdeen. Communicated by Sir MICHAEL FOSTER, K.C.B., Sec. R.S. Received October 24,—Read November 21, 1901.

(Abstract.)

The present investigation has included a very large number of experiments, performed at different times during the last 10 years, the blood-vessels of the ox, horse, and sheep being the ones chiefly examined. The conclusions arrived at apply to the vessels of healthy animals.

Post-mortem Contraction.—The occurrence of *post-mortem* contraction in the arteries is described, and its exciting causes (mechanical stimulation, exposure to air, cooling, &c.) stated, and the remarkable persistence of this contraction over many days—in the case of the horse's carotid kept in olive oil over a fortnight, &c.

The influence of chloroform vapour and saline decoction of suprarenal medulla in causing or increasing contraction are described. Also the method of preventing the occurrence of *post-mortem* contraction by freezing, and various methods of removing contraction when it has once been established, by potassium sulphocyanide, ammonia vapour, heating to 50°—55° C., keeping at 38°—40° C. for 24 hours, &c., or merely keeping at room temperature (in blood) for a number of days. The different effects of sulphocyanide on arterial muscle and on skeletal muscle are illustrated.

Very different measurements (as to lumen, thickness of wall, &c.) are obtained from the same artery in contraction and in relaxation.

Effects of Changes in Temperature.—The effects of changes of temperature have been studied in various ways—by causing strips (transverse and longitudinal) of the vascular wall to act upon recording levers (supported by long, feeble, spiral springs) while the strips were heated in an oil-bath, &c.

Relaxed arteries give results very different from contracted arteries, and generally similar to veins—the chief feature on heating being a very marked shortening at 60°—65° C.

Contracted arteries show a definite series of changes when the temperature is raised. Up till two or three days after death there are usually the following changes:—Shortening between 25° and 35°, lengthening about 40°, shortening at 45°—50°, extensive lengthening at 50°—55°, &c., shortening at 60°—65°; a certain amount of lengthening occurs during subsequent cooling.

When the artery is kept longer these changes show a definite order of disappearance; while any contraction remains there is always relaxation at 50°—55°, while at a later stage, when contraction is

absent, there is only the 60°—65° shortening—with the usual lengthening on cooling. Tracings are given to illustrate these changes. The general behaviour of the arterial muscle is strikingly similar in its general character to what occurs in the bladder (cat), while its muscle is unquestionably alive.

The changes seen in strips from the aorta and the pulmonary artery are slighter in amount (though similar in general character) in accordance with the relatively small amount of muscular tissue in the walls of those vessels.

The effects of heat upon saline extracts of contracted and relaxed arteries are examined and compared with the changes shown by the arterial strips. It is shown that there is no necessary relation between the phases of shortening and the coagulation of proteids in the arterial wall. Coagulation occurs in an acidulated 5 per cent. $MgSO_4$ extract of artery at 45°—50° and at 55°—60°. Experiments were made to ascertain whether proteid coagulation occurred in the tissues of the arterial wall at the same temperatures as in saline extracts.

Contraction v. *Rigor Mortis.*—*Post-mortem* contraction is evidently a true persistent contraction—very different in its character from the *rigor mortis* of skeletal muscle. This is shown by evidence of various kinds—(1) the effects of stimulation; (2) sulphocyanide; (3) heat; (4) the results of extension of strips of the arterial wall by weights; (5) the behaviour of the artery when distended by internal pressure, &c.

Elasticity of the Arterial and Venous Walls.—This was tested by weighting strips cut transversely and longitudinally from the carotid, &c. Relaxed arteries, as well as veins, gave maximum elongation with the first addition of weight, while contracted arteries showed increments of length increasing up to a maximum and then declining, the curve being first convex towards the axis and then concave—in marked contrast to what is obtained with skeletal muscle and other tissues. When stretched a second time the maximal elongation comes at the beginning.

Strips from the aorta and pulmonary artery behave much like strips from a relaxed carotid.

Both the relaxed and contracted arteries show increased extensibility with light weights when stretched a second time.

Illustrative tracings are given in the paper.

Relation of Cubic Capacity to Internal Pressure.—The portion of artery examined was placed in an oil plethysmograph, and the air pressure in the interior of the artery was raised by means of a system of pressure bottles.

Relaxed arteries were found to be most distensible at low pressures; the maximum increase of volume per unit rise of pressure comes when the pressure is raised from zero, as a rule.

Contracted arteries show increasing increments of volume per unit rise of pressure up to a certain maximum, then diminishing increments. In a strongly contracted artery an enormous pressure (several hundred mm. Hg), vastly higher than the normal blood-pressure of the animal, is required in order to obtain the maximal increase of volume; when contraction is weaker, the level of pressure at which extensibility is greatest is much lower (*e.g.*, 100—120 mm.), and when contraction is feeble the maximal increase in volume may occur at 40—60 mm.; it comes immediately above zero when contraction has been completely abolished, as a result of keeping the artery for a number of days in blood, heating to 40° for a number of hours, or to 50°—55° for a few minutes, freezing for some hours, treatment with ammonia vapour, sulphocyanide, &c.

Both contracted and relaxed arteries show increased distensibility when they have already been distended by a previous rise of pressure.

The main features in the behaviour of the artery are shown by diagrams, and numerical details are given.

Elongation of an Artery when Distended by a Rise of Internal Pressure.—Relaxed arteries elongate vastly more than contracted ones when the internal pressure is raised, *e.g.*, from 0 to 300 mm. Hg.

The character of the tracing is very different in the two cases. In the relaxed artery the maximum elongation per unit rise of pressure comes early—usually with the first rise, *e.g.*, from 0 to 50 mm. Hg.

In the contracted artery the elongation with the first rise is small; it gradually increases with subsequent rises—up to a maximum, which in the case of a strongly contracted artery is only reached with pressures much higher than those stated above.

Tracings are given to illustrate the changes in relaxed and contracted arteries.

Pulsatile Expansion of Arteries.—With a succession of sudden, brief elevations of pressure within an artery the pulsatile expansion of the tube is vastly greater in a relaxed artery than in a contracted one. In the former the maximum expansion is got when the brief rise of pressure starts from zero; the expansion becomes smaller at higher pressures. The observations were made with the aid of a plethysmograph.

Among the most important points described in the paper are—

(1.) The remarkable persistence of vitality in the arteries of a healthy animal—for days after the death of the animal.

(2.) The great importance of the presence or absence of *post-mortem* contraction in influencing not only the measurements of the artery but its behaviour in various respects—

(*a.*) Response to changes in temperature.
(*b.*) Extensibility of strips of the arterial wall when weighted.
(*c.*) Relation of cubic capacity to changes in internal pressure.

(*d.*) Elongation accompanying rises of internal pressure.
(*e.*) Pulsatile increase of volume during sudden brief elevations of internal pressure.

The discordant results obtained by various observers (Marey, Roy, and others) as regards the distensibility of arteries, are in large measure explicable by the absence or presence (in varying degree) of *post-mortem* contraction in the arteries they used in their experiments.

"Heredity, Differentiation, and other Conceptions of Biology: a Consideration of Professor Karl Pearson's paper 'On the Principle of Homotyposis.'" By W. BATESON, M.A., F.R.S.

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In his paper on "Homotyposis,"* of which an abstract appeared in the 'Roy. Soc. Proc.,' vol. 68, p. 1, Professor Pearson raises an issue of extraordinary importance. In any attempt to perceive the true relation of variation to differentiation, and to analyse the essential similitude existing between Heredity and Repetition of Parts, we reach a fundamental problem of biology. Little has thus far been done towards elucidating this problem or even towards formulating it. The appearance of Professor Pearson's remarkable memoir may perhaps therefore with profit be taken as an occasion for considering critically some aspects of these questions.

It is impossible to write of Professor Pearson's paper without expressing a sense of the extraordinary effort which has gone to its production and of the ingenuity it displays. But on careful examination it will, I think, be seen that in the light of known facts there is serious doubt whether the determination of what Professor Pearson calls the average homotyposis of "undifferentiated like parts" can be attained by his observations, and that there is even graver doubt whether, if it was attainable, such a value would have any natural significance. In the course of this consideration it must, I think, also appear that the comparison he attempts between the average homotyposis of "undifferentiated like parts" and average fraternal correlation in families is incorrectly instituted.

At the outset I wish to express the conviction that the leading idea which inspired and runs through the work is a true one. Professor Pearson suggests that the relationship and likeness between two brothers is an expression of the same phenomenon as the relationship and likeness between two leaves on the same tree, between the scales on a moth's wing, the petals of a flower, and between repeated parts

* 'Phil. Trans.,' A, 1901, vol. 197, p. 285.